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THE EFFECT OF INDOLE ACETIC ACID ON THE PERFORMANCE OF MAIZE (*Zea mays*L.)IN A SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA.

[1]Eifediyi, E. K and [2] Remison, S.U.

[1]Department of Agronomy, University of Ilorin, Ilorin Nigeria

[2] Department of Crop Science, Ambrose Alli University, Ekpoma, Nigeria

Email address: kevineifediyi@yahoo.ca

ABSTRACT

Poor soil fertility and nutrient depletion continue to present huge challenges to successful crop production in southern Guinea savanna zone of Nigeria. Consequently, a study was conducted at Ilorin - Nigeria in a southern Guinea savanna zone during the wet seasons of 2012 and 2013 to evaluate the effects of indole acetic acid (IAA), a growth regulator, on the growth and yield of maize and its economic implications. The treatments imposed were five rates of IAA (0, 200, 400, 600 and 800 ppm) using a randomized complete block design replicated three times. A basal NPK fertilizer was applied at 3WAP and IAA was applied at the primary leaf stage foliarly. Data were collected on growth parameters and grain yield of maize. Analyses of variance (ANOVA) for all observations were performed and mean separation was done by using the least significant difference (LSD). Cost benefit analysis was also determined. The result of the experiment indicated that using IAA significantly (P<0.05) increased growth and grain yield of maize from 3300 to 3957.9kgha^{-1} but the result of economic analysis indicated that the control produced the highest net returns (N225,130 in 2012 and N232,959.00 in 2013) and was more economical because of high cost of indole acetic acid for maize cultivation.

Keywords: maize, growth regulator, growth, grain yieldand net returns.

INTRODUCTION

Maize (*Zea mays L.*) is very important and useful as human food, livestock feed and raw materials in a number of industries (Abayomi *et al*., 2006) and ranks third in world production of cereals after wheat and rice (Frova *et al*., 1999). The crop is a major component of human and livestock feed especially poultry. In Nigeria, there are wide variations in genotypes of maize having different responses to agro-climatic zones, nutrients, plant morphology (Benga *et al*., 2001) and prolificacy (Boris *et al*., 2004). Maize has immense yield potentials of up to 7.5 tons per hectare with good `management especially if fertilizers are timely applied and weed competition prevented. Unfortunately, yields in the tropics are below 5 tons per hectare (FAO, 2007) and this yield differential per hectare basis had caused severe food shortages and income losses between temperate and tropical areas. This constraint has been attributed to low nutrient status of tropical soils, which are readily leached during rainfall and the use of slash and burn agriculture.

The increase in population, infrastructural development and other human activities have resulted in reduced fallow periods (Steiner, 1991). The low fertility status of most tropical soils had hindered maize production, as maize is a high nutrient demanding crop and generally, the crop fail to produce good yield in plots without adequate nutrients (Adediran and Banjoko, 2003) and inorganic fertilizers play a key role in plant growth and yield (Stefano *et al.,*2004). The nutrients from inorganic fertilizers will lead to improved cell activities, enhanced cell multiplication and enlargement and luxuriant growth (Fashina *et al.,* 2002); which result in high dry matter production (Obi *et al.*, 2005). Some factors, which may also contribute to low yield of maize, are low plant population on farmer's plots, use of unimproved seeds for planting, weeds not controlled especially at critical periods of competition, pests and diseases. In spite of these attributes, the sole application of mineral fertilizer has not been able to bridge the yield differentials between temperate and tropical countries, especially in the Guinea savanna zone where farmers rely solely on inorganic fertilizers for soil fertility maintenance; because of the reduction in fallow periods as a result of increase in population and constant bush fire which deprive the soil of much needed organic matter. .

However, the use of plant growth regulators can help to fill this gap. Plant growth regulators are known to affect growth, flowering and assimilate translocation in plants (Hayat *et al.*, 2001; Naeem *et al.,* 2004). The application of foliar sprays of indole acetic acid (IAA) to the growing media of tomato plants had a stimulating effect on the growth and development of the crop (Hathout *et al.,* 1993). A foliar application of IAA has been found to increase fruit size with consequent increase in seed yield in different crops like groundnut (*Arachis hypogaea* L.) (Lee, 1990), cotton (*Gossypium spp* L.) (Kapgate *et al*., 1989), cowpea (*Vigna unguiculata L.)* (Khalil and Mandurah, 1989) bottle gourd (*Lagenaria siceraria* L*)* (Gaur and Joshi, 1966), rice *(Oryza sativa L.)* (Kaur and Singh, 1987) and mungbeans (*Vigna radiate L.)*(Newaj *et al*., 2002). Mella *et al.* (1997) assert that indole - acetic acid promotes seedling growth in various concentrations. The growth regulators influence plant growth and development at very low concentrations while they inhibit at high concentrations (Jules *et al*, 1981).There is no report on the response of maize to IAA or any other growth regulator in the literature. Hence, the objective of this study was to find out the effect of the application of indole 3 - acetic acid on the growth, grain yield and economic returns on maize.

THE MATERIALS AND METHODS

The experiment was carried out during the wet seasons of 2012 and 2013 at the Teaching and Research Farm of the University of Ilorin, Ilorin (8° 49' N, 4° 49' E and 307 meters above sea level) in a southern Guinea savanna zone of Nigeria. The area is characterized by an annual rainfall of 1186mm, mean annual temperature of 29ºC, while the average annual relative humidity is about 85%. The site was left fallow for two years after it was cropped to maize and cassava prior to the establishment of the experiment in 2012 and in 2013. The land was ploughed and harrowed before soil samples, were collected from 0 - 30 cm depth from fifteen locations prior to planting and after harvesting within the experimental plots. These were bulked and sub- sample taken for chemical characterization. The experiment was laid out as a randomized complete block design with three replications. The treatments consisted of five rates of IAA at 0, 200, 400, 600 and 800 ppm. Maize seeds (SWAN 1) were sown in plots ($20m^2$) with approximate plant population of 53,000 plants/ha on the 15th of July, 2012 and 15th of July 2013. The IAA treatments were applied at 3 weeks after planting, just before basal application of 300kg ha^{-1} of NPK 15: 15:15. Pre-emergence herbicide atrazine was applied at the rate of $3kgaiha^{-1}$, which was followed by a supplementary hoe weeding at 7 weeks after planting. Data were collected on the net plots for vegetative parameters (plant height, number of leaves and leaf area) and yield parameters (shelling percentage, cob length and cob girth, 500 seed weight and weight per hectare). The plant height was assessed by measuring from the base of the plant to the terminal point of the stem; the number of leaves was assessed by visual count of the green leaves and the leaf area was estimated as leaf length multiplied by the widest width, multiplied by a constant, 0.75 (Watts, 1973; Moll and Kamprath, 1977); shelling percentage, cob length and diameter were determined by randomly selecting five cobs from the net plot and measured by using a digital vernier caliper. Weight of grains per plant was determined by using a sensitive balance and the weight per hectare was extrapolated and simple cost benefit analysis was calculated based on cost of production. Analyses of variance (ANOVA) for all measurements were performed using Genstat software version 12 statistical packages for randomized complete block design (RCBD) and mean separation was done based on Steele and Torrie (1980).

RESULTS AND DISCUSSION

The result of the soil analysis before and after the experiment is presented in Table 1. The experimental site was sandy loam and slightly acidic. The data before cropping in 2012 and 2013 clearly showed that the organic matter content, nitrogen, phosphorus and potassium were very low before and after the experiment.

Table 1.Chemical properties of soil of the experimental site before and after cropping in 2012 and 2013

Year	Soil P^H %	Org C %	Org matter %	Total N mg/kg	Avail P. mg/kg	K mg/kg	Ca cmol/kg	Mg cmol/kg
2012a	6.2	1.02	1.76	0.08	3.43	0.32	2.15	0.90
2012b	6.1	0.61	1.05	0.03	2.28	0.11	1.98	0.56
2013a	6.3	1.05	1.82	0.09	3.56	0.28	2.25	0.95
2013b	6.0	0.68	1.18	0.04	2.05	0.09	1.76	0.49

a= before cropping, b= after cropping

The Plant Height

The data on the application of IAA on the plant height of maize at the four sampling periods of 4, 6, 8 and 10 weeks after planting in 2012 and 2013 showed a significant ($P<0.05$) increase in the plant height of maize with increasing IAA application. This was in agreement with the findings of Reena *et al.* (1999). (Newaj *et al.,* 2002) also observed similar results of plant height stimulation in mungbean.Mella *et al.* (1997) reported that indole acetic acid had effects on seedling growth in various concentrations. Mergawi *et al.* (1999) reported the application of IAA had a favorable effect on growth characters.. The increase in plant growth characters of maize could be attributed to enhanced cell division and elongation (Gabal *et al.,* 1999). Amin *et al.* (2006) reported that foliar application of indole butyric acid (IBA) increased the vegetative traits of maize at different stages of growth.

The Number of Leaves

The number of leaves significantly ($P<0.05$) increased with increasing the concentration of IAA and reached a peak at 600ppm and then declined at 800ppm across the four sampling periods (Table 2). The decline in leaf production at 800ppm could be attributed to the fact that at lower concentrations most growth regulators stimulate plant growth and at higher concentrations inhibit plant growth (Jules *et al.*, 1981). The 600ppm treated plots consistently produced the highest number of leaves and the lowest by the 800 treated plots. Similar trend was observed in 2013. Marthur (1971) had earlier reported that IAA at 300ppm increased the number of leaves per plant in onions; Newaj *et al.* (2002) also opined that IAA at 600ppm increased the number of leaves of mungbeans. Similar stimulatory effect of IAA on number of leaves per plant was also reported in cowpea (Khalid and Mandurah, 1989) and wheat (Gurdev and Saxena, 1991). Nevertheless, the result of this study on the number of leaf production was in contrast with the findings of Remison *et al.* (2002) who reported that IAA reduced the number of leaves but greatly increased tuber weight in cassava.

The Leaf Area

The application of IAA also affected the leaf area of maize and the result showed that at 4WAP, the 600ppm treated plants (176.61cm^2) produced the highest leaf area and the 800ppm treated plants (157.77cm^2) produced the lowest (Table 2). At 6 and 8WAP, the highest leaf area was produced by the 600ppm treated plots and the lowest was recorded by the control. Similarly, at 10 WAP the leaf area of maize increased with increasing concentration up to the 600ppm (549.2cm^2) treated plots, then declined at 800ppm (496.3cm^2) .

The data on the leaf area per plant as affected by IAA in 2013 are also presented (Table 2). At 4 WAP, the leaf area of maize increased with increasing concentration of IAA up to the 600ppm and then declined at 800ppm. However, no significant difference was observed between their means. At 6 WAP, the data indicated that as the level of concentration of IAA, increased the leaf area also increased up to 600ppm and then declined at 800pmm. The highest leaf area was however, produced by the 600pmm treated plots and the lowest was produced by the control. At 8 and 10 WAP, the result followed the similar trend. Data on the leaf area across the two years of study indicated a significant increase in the leaf area with increase in the concentration of IAA. This was in conformity with the findings of Baz *et al*. (1984), Velu (1999), (Govinda *et al.,* 2000) and Abdo and Abdel-Aziz (2009) who reported that plants treated with foliar sprays of IAA showed pronounced increase in their leaf area. Touminen *et al.* (1997) reported that IAA plays a part in leaf area enlargement.

Table 2: The effects of indole -3- acetic acid on the vegetative growth of maize at 4, 6, 8 and 10weeks after planting in 2012 and 2013

Year	IAA ppm	Plant height (cm) WAP				Number of leaves /plant WAP				Leaf area/plant WAP			
		4	6	8	10	4	6	8	10	4	6	8	10
	0	24.4	47.63	144	182.8	5.33	6.9	8.77	10.57	163.77	217.7	319.2	531.4
	200	27.1	50.47	146.6	184.2	5.43	7.1	8.87	10.73	167.5	231.7	327.7	538.5
2012	400	28.9	51.2	151.5	187	5.5	7.27	9.03	10.83	171.8	245.7	338.3	540.7
	600	31.1	52.87	154.1	189.9	5.57	7.6	9.13	10.97	176.61	258.8	348.8	549.2
	800	28.8	42.87	134.2	167.3	3.93	5	8.17	8.3	157.77	222.4	328.8	496.3
	Mean	27	49.01	146.1	182.2	5.15	6.77	8.79	10.28	167.49	235.3	332.6	530.6
	LSD(0.05)	2.99	1.117	3.888	8.84	0.56	1.22	0.08	1.032	6.408	22.69	2.68	7.6
	0	24	47.4	143	169.4	4.1	7.57	8.23	10.43	166.4	213.9	314	548.7
	200	26.4	4950	145.4	171	5.17	7.77	8.87	11.37	171.03	229.3	320.3	550.5
	400	27.7	50.03	147.9	175.2	5.3	7.9	9.27	11.57	175.27	238.9	326.3	556.3
	600	31	51.9	152.7	178.3	5.57	8.17	9.67	11.83	178.43	253.8	333.8	560.7
	800	25.4	41.87	132.8	146	3.67	7.2	8.2	10.1	165.9	240.7	311.5	484.9
	Mean	26.9	48.18	144.3	167.9	4.76	7.72	8.85	11.06	171.4	235.3	321.2	540.2
	LSD(0.05)	3.01	2.178	4.035	20.59	1.42	0.18	0.79	0.426	10.7	11.09	11.17	15.12

The Yield and Yield Components

In 2012, indole acetic acid reduced the number of days to tasselling, especially at the highest level applied (Table 3). The data on lodging percentage revealed that the lowest percentage of lodged plants were observed in the 800ppm treated plots and the highest in the control but no significant difference was observed among the treated plots and the control. In 2013, IAA had no significant effects on flowering and lodging in maize. Cob length, cob girth and weight of seeds were significantly ($P<0.05$).increased with IAA application up to an optimum of 600ppm (Table 3). However, in 2013 the effects of the growth regulator on cob length and girth were similar to those recorded in 2012; there were increases in these components up to the optimum of 600ppm applied. Grain yield and shelling percentage were also significantly increased ($P<0.05$) up to an optimum of 600ppm. The data on the yield components as affected by IAA in 2013 were similar to what happened in 2012 except the lodging percentage, days to tasselling and 500 seed weight, which were not significantly different from the control.The Effects of IAA on cob length and girth (Table 3) across the two years of study revealed that the longest cob was produced by the 600 ppm rate of application. Saha *et al*. (1989) had earlier reported that the application of IAA on wheat increased ear, spikelet and grain lengths. Chhun *et al.* (2004) asserted that IBA increased the yield of rice and wheat. A foliar application of IAA has been found to increase fruit size with consequent enhancement in seed yield in different crops such as groundnut (Lee, 1990), cotton (Kapgate *et al.* 1989), cowpea (Khalil and Mandurah, 1989), bottle gourd (Gaur and Joshi, 1966) and rice (Kaur and Singh, 1987). IAA was found to have excellent role as plant growth promoter and is reported to produce larger fruits (Raven *et al.,* 1976). IAA greatly increased tuber weight in cassava (Remison *et al*., 2002), pronounced effect on grain filling resulting in increase in the number of filled pods and greater seed size in beans (Lucas and Milbourn, 1977). Data on the 500 seed weight of maize across the two years of study (Table 3) indicated a significant response from the application of IAA. Foliar application of IAA increased 1000 seeds weight of grasspea (Rahman *et al*.,1989),wheat; (Gurdev and Saxena,1991; Tan *et al.* 1995; Saha *et al.,* 1996).

Data on the effects of IAA on grain yield of maize across the two years of study (Table 3) indicated that there was a significant difference between the treated plots and the control. The result of this study was in agreement with the findings of Awan and Alizat (1989), Sontakey *et al*. (1991) and Reena *et al. (*1999) who reported that IAA increased the seed yield of rice, sesame and soybeans respectively and Ashraf *et al.* (2006) who reported that IAA was successfully used to enhance the growth and yield of barley cultivars.

Table 3: The effects of indole acetic acid on the yield components of maize in 2012 and 2013

YEAR	IAA applied (ppm)	Lodging Percentage	Days to tasseling	Cob length (cm)	Cob girth (cm)	500seeds weight (g)	Grain yield (kgha^{-1})	Shelling Percentage
	O	7.80	75.70	15.70	4.27	127.1	3557	76.57
	200	7.70	74.30	16.63	4.37	129.2	3650	76.63
2012	400	7.60	73.70	17.13	4.77	130.3	3789	77.23
	600	7.60	72.87	17.63	4.93	131.7	3898	79.50
	800	7.37	72.60	16.37	4.43	122.0	3300	69.50
	Mean	7.61	73.83	16.69	4.55	128.1	3639.0	75.89
	LSD(0.05)	Ns	0.48	0.508	0.408	2.347	121.6	0.582
	O	8.07	77.27	15.87	4.20	124.7	3644.1	79.17
	200	8.03	77.10	16.07	4.30	126.2	3721.6	79.27
2013	400	7.97	77.10	16.50	4.43	127.2	3792.2	79.83
	600	6.53	76.33	17.83	5.03	129.5	3957.9	79.87
	800	6.37	76.30	16.10	3.97	122.8	3398.0	78.83
	Mean	7.39	76.82	16.47	4.38	126.1	3703.0	79.37
	LSD(0.05)	Ns	Ns	0.608	0.090	NS	315.6	0.627

The Economic Analysis

A simple cost and the benefit analysis on the application of indole -3- acetic acid for 2012 and 2013 cropping seasons are presented in Table 4. The results showed that across the two years of study, it was observed that the control had superior gross margin (profits) when compared to the other treatments where indole acetic acid was used. The control treatments also gave a higher return per investment across the two-years. This is an indication that, it is economically unwise to use IAA to increase the yield of maize in the study area at the moment because of its high cost.

Table 4. The economic analysis of using indole 3 acetic acid on maize in 2012 and 2013 in Naira

Year	Treatments IAA (ppm)	Total Revenue (Sales) (a)	Total Cost (b)	Gross Margin (c= a – b)	Return per Investment (d = c/b)
	0	320,130.00	95,000.00	225,130.00	2.37
	200	328,500.00	118,500.00	210,000.00	1.77
2012	400	341,010.00	143,500.00	197,510.00	1.38
	600	350,820.00	158,500.00	192,320.00	1.21
	800	297,000.00	188,500.00	108,500.00	0.58
	0	327,969.00	95,000.00	232,969.00	2.45
	200	334,944.00	118,500.00	216,444.00	1.83
2013	400	341,298.00	143,500.00	197,798.00	1.38
	600	356,211.00	158,500.00	197,711.00	1.25
	800	305,820.00	188,500.00	117,320.00	0.62

CONCLUSION

From the results of the study, the 600ppm treated plots produced the highest growth and yield parameters significantly; however, the cost benefit analysis indicated that the control gave the highest gross margin (profits) for the two years of study indicating a higher cost of production from the use of indole -3- acetic acid. The current price of IAA is responsible for this high cost of production and the cost of the growth regulator is beyond the reach of peasant farmers. However, more work needs to be done by using low cost growth hormone such as coconut milk, which is inexpensive and readily available.

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